

Claims

1. Method for the regulation and control of digitally and analogically adjustable shock absorbers, preferably in a two-axled road vehicle, where the shock absorbers are controlled according to the situation by means of a control signal such that the road performance of the vehicle is improved when understeering or oversteering occurs, characterized in that phase magnitudes are determined, from which the phases of the control signals are calculated, and in that, in the case of a driving situation with a tendency to sway, a moment in time is determined, as a function of at least the magnitudes which describe the rotation of the vehicle about the vertical axis, when a correct phase control of the shock absorbers of the vehicle is carried out to increase the steerability when understeering occurs and to increase the driving stability when oversteering occurs.
2. Method according to Claim 1, characterized in that a correct phase control occurs as a function of the yaw rate and at least one derivative of the yaw rate.
3. Method according to Claim 1 or 2, characterized in that the deviations between a reference yaw rate which is determined according to a model and the actually measured yaw rate of the vehicle as well as the difference between the gradients of the two gradients, that is the reference yaw acceleration and the actual yaw acceleration of the vehicle, are determined, and in that, from the differences of the yaw values accurate phase switching moments in time are determined, between which the shock absorbers of the wheels can be switched in steps or continuously to hard or to soft.
4. Method according to Claim 3, characterized in that the reference yaw rates are determined in a linear single-track model.
5. Method according to one of Claims 1 to 4, characterized in that the control concept is a part of an ESP control strategy, and the signals, such as steering angle, transverse acceleration and/or longitudinal speed v , of an ESP control are used for the determination of the driving situation and/or of the control signal.

6. Method according to one of Claims 1 to 5, characterized in that an understeering behavior in the left curve is recognized if the condition $\dot{\psi}_{ref} > \dot{\psi} + \varepsilon_1$ and $\ddot{\psi}_{ref} > \ddot{\psi} + \varepsilon_2$ is satisfied, and in that an understeering behavior in the right curve is recognized if the condition $\dot{\psi}_{ref} < \dot{\psi} - \varepsilon_1$ and $\ddot{\psi}_{ref} < \ddot{\psi} - \varepsilon_2$ is satisfied, and in that, if an understeering behavior is recognized in any of the two directions, the shock absorbers of the fronts wheels are switched to soft and those of the back wheels are switched to hard.
7. Method according to one of Claims 1 to 6, characterized in that an oversteering behavior in left curve is recognized if the condition $\dot{\psi}_{ref} \leq \dot{\psi}$ and $\ddot{\psi} > \varepsilon_3$ is satisfied, and in that an oversteering behavior in right curve is recognized if the condition $\dot{\psi}_{ref} \geq \dot{\psi}$ and $\ddot{\psi} < -\varepsilon_3$ is satisfied, and in that, if an oversteering behavior is recognized in any of the two directions, the shock absorbers of the front wheels are switched to hard and those of the back wheels are switched to soft.
8. Method according to one of Claims 1 to 7, characterized in that a neutral behavior of the vehicle is recognized if, after an understeering behavior occurred, the condition $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ and $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ is satisfied, or if, after oversteering occurred, the condition $-\varepsilon_3 \leq \ddot{\psi} \leq \varepsilon_3$ is satisfied, or if, after the occurrence of an uncritical behavior, the condition $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ and $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ and $|a_y| > \varepsilon_4$ is satisfied, and in that, if a neutral behavior is recognized, the shock absorbers of the front wheels and the back wheels are all switched to medium to high damping.
9. Method according to one of Claims 1 to 8, characterized in that an uncritical road performance is recognized after the occurrence of a neutral behavior, because the condition $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ and $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ and $|a_y| < \varepsilon_5$ is satisfied, and in that, if an uncritical behavior is recognized, the shock absorbers are again switched to the state which corresponds to the standard control strategy used.

10. Method according to one of Claims 1 to 9, characterized in that the damping of the shock absorbers does not only occur in the discreet steps soft, medium, hard, but continuously, where the amount of damping depends on the given driving situation.
11. Method according to one of Claims 1 to 10, characterized in that amount of the continuously regulated damping depends on the dynamics of the given driving situation, and in that one includes, in the evaluation of the dynamics of movement, at least the yaw rate and/or the yaw acceleration of the vehicle, the reference yaw rate and/or the reference yaw acceleration as well as the transverse acceleration of the vehicle.
12. Method according to one of Claims 1 to 11, characterized in that the values of the signals which are determined for the evaluation of the dynamics of movement are weighted using the longitudinal speed of the vehicle.
13. Method according to one of Claims 1 to 12, characterized in that for the evaluation of the dynamics of movement one uses not only the currently measured or calculated dynamics of movement signals at a certain time, but also the course of these signals within a past time interval $\dots\Delta T\dots$, where the maximum values of the signals are stored and they are unlearned over the course of time by linear or degressive reduction.
14. Method according to one of Claims 1 to 13, characterized in that the control of the shock absorbers with the phase-correct control signal is superposed by addition over the requirements of additional shock absorber control mechanisms (for example, skyhook control strategy).
15. Method according to one of Claims 1 to 14, characterized in that the amount of the additive superposition of different requirements for the shock absorbers is established by the reached amount of the dynamics of movement and, in the case of high dynamics of movement, a high proportion of up to 100% is requested, while, in the case of lower dynamics of movement, only a small portion of as little as 0% is requested and superposed over a correspondingly large portion of an additional control strategy.
16. Method according to one of Claims 1 to 15, characterized in that all the thresholds ε are adapted, for the determination of the driving situation, to the reaction times which occur

during the data transfer between the controller and the adjustment elements (shock absorbers), and the delay times are adapted to the adjustment elements, where, in the case of a larger sum of reaction time and delay time, smaller thresholds are used so that the switching reaction occurs on time.

17. ESP control characterized by a method according to one of Claims 1 to 16.
18. Device for the control and/or adjustment of the digitally or analogically adjustable shock absorbers, preferably in a two-wheeled road vehicle, where the shock absorbers are controlled according to the situation in such a manner that the road performance of the vehicle is improved when understeering or oversteering occurs, characterized by a determination unit (200) for the determination of phase magnitudes, for which the phases of the control signals are calculated, of an additional [sic; an additional] determination unit (230) for the determination of a driving situation with a tendency to sway and of a control [sic; a control] and control unit (220, 210), which, as a function of at least the magnitudes describe [sic; which describe] the rotation of the vehicle about the vertical axis, determines a moment in time, at which a correct phase control of the shock absorbers of the vehicle is carried out to increase the steerability when understeering occurs and the driving stability when oversteering occurs.
19. Device according to Claim 18, characterized in that the determination unit (200) determines the deviation between the reference yaw rate which has been determined according to a linear single-track model and the actually measured yaw rate of the vehicle as well as the difference between the gradients of the two yaw rates, that is the reference yaw acceleration and the actual yaw acceleration of the vehicle, and in that the regulation and control unit (220, 210), with inclusion of the determination unit (230), determines phase-accurate switching moments in time from the yaw magnitudes, between which moments in time the shock absorbers of the 4 wheels are switched to hard or soft in steps or continuously.
20. Device according to Claim 18, characterized in that the control concept is part of an ESP control strategy and includes the signals of the ESP control in the regulation and/or control of the shock absorbers.

21. Device according to Claim 20, characterized in that it is part of an ESP controller.
22. Device according to one of Claims 18 to 21, characterized in that the determination unit (230) recognizes an understeering behavior in the left curve if the condition $\dot{\psi}_{ref} > \dot{\psi} + \varepsilon_1$ and $\ddot{\psi}_{ref} > \ddot{\psi} + \varepsilon_2$ is satisfied, and an understeering behavior in the right curve if the condition $\dot{\psi}_{ref} < \dot{\psi} - \varepsilon_1$ and $\ddot{\psi}_{ref} < \ddot{\psi} - \varepsilon_2$, and in that, if understeering behavior is recognized in any of the two directions, the determination unit (230) generates a signal which is used to switch the shock absorbers of the front wheels to soft and those of the back wheels to hard.
23. Device according to one of Claims 18 to 21, characterized in that the determination unit (230) recognizes an oversteering behavior in a left curve if the condition $\dot{\psi}_{ref} \leq \dot{\psi}$ und $\ddot{\psi} > \varepsilon_3$ is satisfied, and an oversteering behavior in a right curve if the condition $\dot{\psi}_{ref} \geq \dot{\psi}$ and $\ddot{\psi} < -\varepsilon_3$ is satisfied, and in that, if oversteering behavior is recognized in any of the two directions, the determination unit (230) generates a signal which is used to switch the shock absorbers of the front wheels to hard and those of the back wheels to soft.
24. Device according to Claims 18 to 23, characterized in that a determination unit (230) recognizes a neutral behavior of the vehicle if, after the occurrence of an understeering behavior, the condition $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ und $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ is satisfied, or if, after the occurrence of an oversteering behavior, the condition $-\varepsilon_3 \leq \ddot{\psi} \leq \varepsilon_3$ is satisfied, or if, after the occurrence of an uncritical behavior, the conditions $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ and $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ and $|a_y| > \varepsilon_4$ are satisfied, and in that, if neutral behavior is recognized, the determination unit (230) generates a signal which is used to switch the shock absorbers of the front wheels and back wheels equally to medium to high damping.
25. Device according to one of Claims 18 to 24, characterized in that the determination unit (230) recognizes an uncritical road performance after the occurrence of a neutral behavior if the condition $|\dot{\psi}_{ref} - \dot{\psi}| < \varepsilon_1$ and $|\ddot{\psi}_{ref} - \ddot{\psi}| < \varepsilon_2$ and $|a_y| < \varepsilon_5$ is satisfied, and in that, if uncritical behavior is recognized, the determination unit generates a signal which is used to

switch the shock absorbers back to the state which corresponds to the standard control strategy used.

26. Device according to one of Claims 18 to 25, characterized in that the regulation and control unit (220, 210) does not adjust the damping of the shock absorbers only in the discreet steps soft, medium, hard, but continuously, where the amount of damping depends on the given driving situation.
27. Device according to one of Claims 18 to 26, characterized in that the control and regulation unit (220, 210) determines the amount of the continuously adjusted damping from the dynamics of the given driving situation, where, as relevant signals for the evaluation of the dynamics of movement, one takes into account the yaw rate and/or the yaw acceleration of the vehicle, the reference yaw rate and/or reference yaw acceleration, as well as the transverse acceleration of the vehicle.
28. Device according to one of Claims 18 to 27, characterized in that the values of the signals which are used for the evaluation of the dynamics of movement are weighted by means of the longitudinal speed of the vehicle.
29. Device according to one of Claims 18 to 28, characterized in that, for the evaluation of the dynamics of movement, one uses not only the currently measured or calculated dynamics of movement signals at a moment in time, but also the course of the signals within a past time interval ...delta_T..., where the maximum values of the signals are stored and they are unlearned by linear or degressive reduction over time.
30. Device according to one of Claims 18 to 30, characterized in that the control of the shock absorbers, after the [incomplete text], is superposed additively over the requirements of other shock absorber control mechanisms (for example skyhook control strategy).
31. Device according to one of Claims 18 to 31, characterized in that the amount of the additive superposition of different requirements for the shock absorbers is determined by the reached amount of the dynamics of movement, and in that, in the case of high dynamics of movement, a high proportion of up to 100% is requested, while, in the case of lower

dynamics of movement, only a small proportion as low as 0% is requested and superposed over an accordingly high proportion of another control strategy.

32. Device according to one of Claims 18 to 31, characterized in that all thresholds for the determination of the road situation are adapted to the reaction times which occur during the data transfer between the controller and the adjustment elements (shock absorbers) as well as to the delay times of the adjustment elements, where smaller thresholds are used in the case of a larger sum of reaction time and delay time so that the switching reaction occurs on time.